

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,062,704 B2
APPLICATION NO. : 09/880616
DATED : June 13, 2006
INVENTOR(S) : Nisha D. Talagala, Randall D. Rettberg and Chia Y.

Page 1 of 6

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims:

Column 18, line 39 through column 22, line 54 and delete claims 1-54 and insert the following:

--1. A storage system comprising:

a storage array controller; and

a storage array coupled to the storage array controller by an interconnect,
wherein the storage array comprises a plurality of storage devices;

wherein the storage array controller is configured to write data to a first data range in the storage array, wherein the first data range comprises one or more units of data, wherein the storage array controller is further configured to initiate an extent scrubbing operation for the first data range, wherein the extent scrubbing operation comprises reading the data from the first data range from the one or more storage devices comprised in the storage array, calculating an extent checksum for the data read from the first data range, and comparing the extent checksum to a preexisting extent checksum for the first data range;

wherein if the extent checksum differs from the preexisting extent checksum, the storage array controller is further configured to initiate one or more unit scrubbing operations, wherein each unit scrubbing operation comprises calculating a new unit checksum for a first unit of data, wherein the first unit of data is comprised within the first data range, and comparing the new unit checksum to an existing unit checksum for the first unit of data.

2. The storage system of claim 1, wherein the storage array controller is further configured to determine that an error is located within the first unit of data if the new unit checksum differs from the existing unit checksum.

3. The storage system of claim 1, wherein the storage array controller is further configured to calculate a plurality of existing unit checksums for the units of data comprised within the first data range in conjunction with writing the data to the first data range.

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Column 18, line 39 through column 22, line 54 and delete claims 1-54 and insert the following: (cont'd)

4. The storage system of claim 1, wherein the storage array controller is further configured to initiate a unit scrubbing operation for each unit of data within the first data range.

5. The storage system of claim 1, further comprising one or more storage device controllers, wherein each storage device controller is configured to control one or more of the storage devices, wherein the storage array controller is further configured to initiate the extent scrubbing operation by issuing an extent scrubbing operation command to one or more of the storage device controllers, and wherein the one or more of the storage device controllers are configured to perform the extent scrubbing operation in response to receiving the extent scrubbing operation command by reading the data from the first data range, calculating the extent checksum, comparing the extent checksum to the preexisting extent checksum, and if the extent checksum differs from the preexisting extent checksum, indicating that the data within the first data range is erroneous to the storage array controller.

6. The storage system of claim 5, wherein the storage array controller is further configured to initiate multiple extent scrubbing operation commands by issuing multiple extent scrubbing operation commands in parallel to multiple ones of the storage device controllers.

7. The storage system of claim 1, further comprising one or more storage device controllers, wherein each storage device controller is configured to control one or more of the storage devices, wherein the storage array controller is further configured to initiate the one or more unit scrubbing operations by issuing one or more unit scrubbing operation commands to one or more of the storage device controllers, wherein the one or more of the storage device controllers are configured to perform the one or more unit scrubbing operations in response to receiving the one or more unit scrubbing operation commands by calculating the new unit checksum for the first unit of data, comparing the new unit checksum to the existing unit checksum for the first unit of data, and if the new unit checksum differs from the existing unit checksum, indicating that the first unit of data is erroneous to the storage array controller.

8. The storage system of claim 1, wherein the storage array controller is further configured to read the data from the first data range, calculate the extent checksum, and compare the extent checksum to the preexisting extent checksum.

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Column 18, line 39 through column 22, line 54 and delete claims 1-54 and insert the following: (cont'd)

9. The storage system of claim 1, wherein the storage array controller is further configured to initiate a reconstruction attempt of the first unit of data in response to determining that the error is located within the first unit of data.
10. The storage system of claim 1, wherein the storage array controller is further configured to calculate the preexisting checksum for the data when the data is written to the storage array.
11. The storage system of claim 1, wherein the storage array controller is further configured to receive the preexisting checksum from a host computer system when the host computer system writes the data to the storage array.
12. The storage system of claim 1, wherein the storage array controller is further configured to maintain the preexisting checksum in a cache coupled to the storage array controller.
13. The storage system of claim 1, wherein the storage array controller is further configured to perform multiple scrubbing operation commands in parallel by reading data from multiple storage devices.
14. The storage system of claim 1, wherein the storage array controller is implemented in software running on a host computer system.
15. The storage system of claim 1, wherein the storage array controller is further configured to store the preexisting checksum in a checksum location that is independent of a location where the data within the data range is stored.
16. The storage system of claim 1, wherein the data range is a multi-unit data range, and wherein the storage array controller is further configured to calculate the preexisting checksum directly from the data in the multi-unit data range.
17. The storage system of claim 1, wherein the first data range is a multi-unit data range, and wherein the storage array controller is further configured to calculate the preexisting checksum from a plurality of unit checksums that each correspond to a unit within the multi-unit data range.

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18. The storage system of claim 17, wherein the storage array controller is further configured to calculate the preexisting checksum on the fly when initiating the extent scrubbing operation.

19. The storage system of claim 17, wherein the multi-unit data range is a multi-byte data range.

20. The storage system of claim 17, wherein the multi-unit data range is a multi-block data range.

21. A method of performing scrubbing operations in a storage array, comprising:

writing data to a first data range on one or more storage devices comprised in the storage array;

initiating a scrubbing operation for the first data range;

in response to said initiating:

reading the data from the first data range on the one or more storage devices comprised in the storage array;

calculating an extent checksum for the data read from the first data range;

comparing the extent checksum to a preexisting extent checksum for the first data range; and

if the extent checksum differs from the preexisting extent checksum:

calculating a new unit checksum for a second data range,
wherein the second data range is a subset of the first data range,

comparing the new unit checksum to an existing unit checksum for the second data range; and

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if the new unit checksum differs from the existing unit
checksum, determining that the error is located within
the second data range.

22. The method of claim 21, wherein a storage array controller performs said calculating and said comparing in response to said initiating.
23. The method of claim 22, wherein a storage device controller configured to control one or more storage devices on which a portion of the data in the first data range is stored performs said calculating and said comparing in response to said initiating.
24. The method of claim 21, wherein said writing data to the first data range further comprises calculating the preexisting extent checksum directly from the data written to the first data range.
25. The method of claim 24, wherein the preexisting extent checksum is calculated using a different algorithm than was used to calculate the one or more checksums for the first data range.
26. The method of claim 21, wherein said writing comprises calculating one or more existing unit checksums for the first data range.
27. The method of claim 26, wherein said initiating further comprises calculating the preexisting checksum from the one or more unit checksums for the first data range.
28. The method of claim 26, wherein the one or more existing unit checksums for the first data range each correspond to a block of data within the first data range.
29. The method of claim 26, wherein a storage array controller performs said calculating one or more existing unit checksums.
30. The method of claim 26, wherein a host computer system performs said calculating one or more existing unit checksums.

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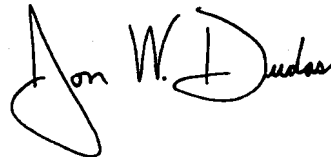
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Column 18, line 39 through column 22, line 54 and delete claims 1-54 and insert the following: (cont'd)

31. The method of claim 21, further comprising initiating a reconstruction attempt of data within the second data range in response to said determining.-- in place thereof.

Signed and Sealed this

Tenth Day of July, 2007

A handwritten signature in black ink, appearing to read "Jon W. Dudas". The signature is stylized with a large, looping initial "J" and a distinct "D".

JON W. DUDAS
Director of the United States Patent and Trademark Office